REAL-TIME ATTENDANCE TRACKING USING ADAPTIVE FACIAL AND IRIS RECOGNITION TECHNIQUES

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Abstract: This paper presents a novel adaptive attendance system utilizing both facial and iris recognition for robust identity verification. The system employs ArcFace for facial feature extraction and a Convolutional Neural Network (CNN) for iris recognition, particularly effective in cases where faces are partially occluded by masks or hijabs. It dynamically switches between facial and iris recognition based on face occlusion detection, ensuring uninterrupted authentication. Attendance is logged according to predefined schedules in an Excel sheet, and a separate late attendance sheet is generated if a person is recognized after 10 minutes of session commencement. The system is implemented without anti-spoofing mechanisms and is deployed on a machine with an RTX 4060 GPU. Extensive experiments demonstrate the system’s efficiency and practical viability for real-time attendance tracking. The system offers a flexible, contactless, and reliable solution to modern attendance management challenges, maintaining high accuracy even with partial occlusions.

Keywords: Face recognition, Iris recognition, Deep learning, Attendance system, Adaptive recognition

1. INTRODUCTION

This paper presents an innovative adaptive attendance system that intelligently alternates between facial and iris recognition, dynamically selecting the appropriate modality based on the visibility of the user's face and confidence scores from the facial recognition model. The system is specifically designed to handle common challenges such as occlusions caused by masks or facial coverings, which can hinder traditional facial recognition methods. When such occlusions are detected, the system seamlessly switches to iris recognition, utilizing pre-collected eye images that provide an effective alternative in these conditions. This dual-mode approach offers significant advantages in inclusivity, ensuring that individuals who are unable to fully reveal their face due to cultural, personal, or medical reasons are not excluded from the attendance system. The facial recognition module leverages ArcFace, a state-of-the-art deep learning model that excels in large-scale face recognition tasks, providing robust accuracy even in suboptimal lighting and partial occlusions. For iris recognition, the system employs a lightweight Convolutional Neural Network (CNN) tailored for efficient real-time performance, ensuring fast and accurate identification even in challenging conditions.

The entire system is optimized for performance using GPU acceleration from the powerful NVIDIA RTX 4060 graphics card, enabling real-time processing of facial and iris recognition tasks with minimal latency. This hardware setup ensures that the system can handle large-scale deployments, making it highly suitable for environments where high throughput and quick response times are critical. In addition to the recognition modules, the system is integrated with an Excel-based session schedule that tracks attendance against pre-defined session times, automating the logging of student attendance. Late arrivals are automatically flagged and recorded in a separate dataset, ensuring that attendance data is accurately captured for both on-time and latecomers. The modular design of the system allows for easy scalability and future enhancements, such as integrating additional recognition methods or expanding the scope to support multi-camera setups. The overall design prioritizes hygiene and contactless operation, aligning with contemporary demands for safe, efficient, and reliable attendance systems in educational or corporate environments. The system is not only fast and accurate but also adaptable to the diverse needs of users, providing a seamless and inclusive experience for all individuals, regardless of face visibility.

Furthermore, the system's flexibility allows for easy updates and customization, ensuring that it can evolve to meet emerging challenges in facial and iris recognition technology. As the system continues to be refined, potential integrations with other biometric modalities, such as fingerprint or voice recognition, could further enhance its robustness. With ongoing research and development, this adaptive attendance system has the potential to set new standards for contactless authentication in various sectors.

2. MATERIALS AND METHOD

2.1 PROPOSED METHODOLOGY

The Adaptive Facial and Iris-Based Attendance System addresses the challenges of face recognition in constrained conditions such as mask-wearing or cultural attire (e.g., hijab). The system leverages two models: ArcFace for face recognition and a custom Convolutional Neural Network (CNN) for iris-based recognition when the full face is not visible. A mask detection model is integrated to switch between these two modes dynamically. Once a student's face is detected, if a mask is identified, the system captures the eye region and initiates iris-based recognition. The model logs attendance only within the first 10 minutes of a scheduled session, referencing a session schedule stored in an Excel sheet (session_schedule.xlsx). Attendance outside this window is marked as late and saved in a separate Excel sheet (late_attendance.xlsx). The system operates on a local machine equipped with an NVIDIA RTX 4060 GPU and utilizes TensorFlow and InsightFace libraries. The full pipeline is designed to handle real-time video input with minimal latency, ensuring practical usability in institutional settings.

2.2 PERFORMANCE METRICS MEASUREMENT

To evaluate the efficacy of the proposed system, we use standard performance metrics for biometric systems, including accuracy, precision, recall, F1 score. These metrics are essential for evaluating the system's ability to correctly identify individuals under varying conditions.

The confusion matrix used for performance measurement is defined as:

- **True Positive (TP)**: Number of correctly identified individuals.
- **True Negative (TN)**: Number of correctly identified non-attendees.
- **False Positive (FP)**: Number of incorrectly identified non-attendees.
- **False Negative (FN)**: Number of incorrectly identified attendees.

For semantic segmentation efficacy, performance measurements such as accuracy, precision, recall, and F1 score are typically employed. They were based on the confusion matrix of the test dataset. They defined as:

Accuracy = $\frac{TP+TN}{TP+TN+FP+FN}$

Recall = $\frac{TP+TN}{TP+FN}$

Precision = $\frac{TP+TN}{TP+FP}$

F1score = 2 * $\frac{Precision*Recall}{Precision+Recall}$

2.3 DATASET

The system uses a custom dataset:

- Facial images of enrolled students stored in face_dataset/
- Eye-region crops for masked/hijab-covered faces in iris_images/

Both sets are labeled appropriately for supervised training and evaluation. The iris images are used exclusively for validation when facial recognition is hindered.

2.4 EXPERIMENTAL SETUP

The system was developed and tested on:

- **GPU:** NVIDIA RTX 4060
- **Frameworks:** TensorFlow (CNN, mask detection), InsightFace (ArcFace)
- **Environment:** Python 3.10, OpenCV, Pandas
- **OS:** Windows 11Pro

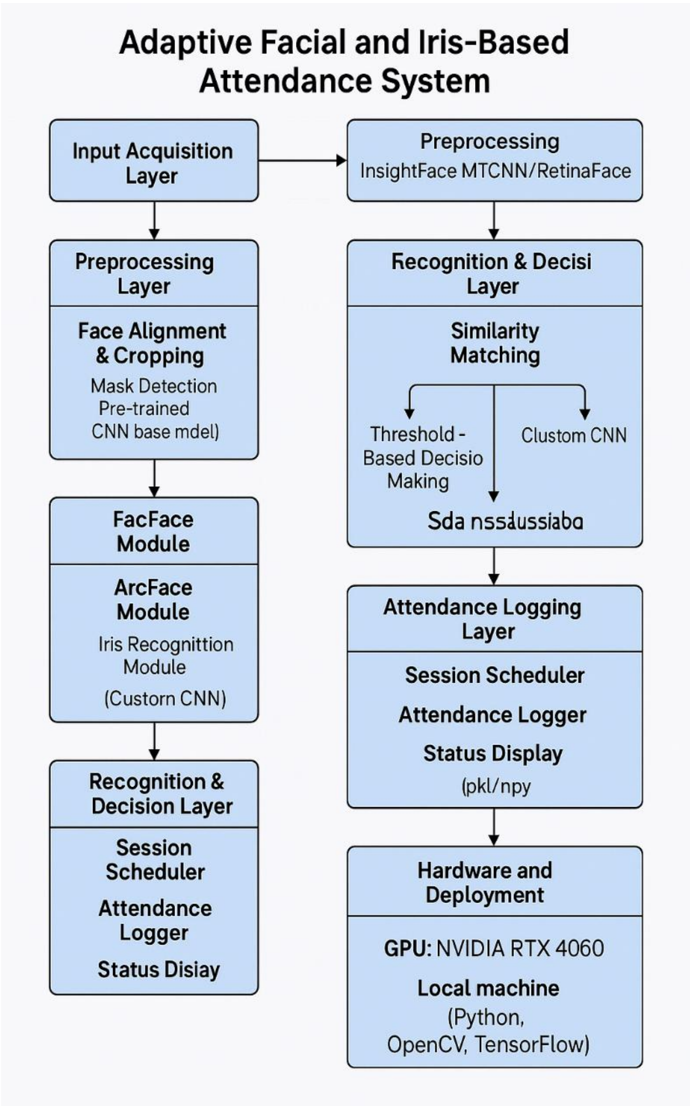

Fig. 1 System Architecture

2025-04-22 00:00:00	Session1	19:00:00	23:59:00	TeacherC	Chemistry
2025-04-23 00:00:00	Session1	19:00:00	23:59:00	TeacherC	Chemistry
2025-04-29 00:00:00	Session1	08:00:00	09:00:00	TeacherC	Chemistry
2025-04-29 00:00:00	Session2	10:00:00	12:00:00	TeacherC	Math
2025-04-29 00:00:00	Session3	09:00:00	10:00:00	TeacherC	Biology

Fig. 2 Session Schedule

Fig. 3 Face_dataset

3. SYSTEM ARCHITECTURE

The proposed system is designed to operate in real-time, accurately marking attendance through facial and iris recognition mechanisms. The system follows a modular architecture, which is illustrated in Figure 1. The architecture consists of the following main components:

Camera Input: Captures real-time video frames from the classroom.

Face Detection Module: Detects faces in the frame using MTCNN.

Mask Detection Module: Determines whether a face is covered with a mask or hijab.

Recognition Decision Module:

- If no mask is detected, facial features are extracted using the ArcFace model.
- If a mask/hijab is detected, iris images are cropped and passed through a trained CNN model.

Matching and Verification:

- Features are matched against a pre-registered database.
- If a match is found, the identity is confirmed.

Attendance Logging:

- The session schedule is fetched from an Excel file.
- Attendance is logged only if the student appears within the first 10 minutes.
- Latecomers are logged in a separate sheet.

This architecture allows adaptive decision-making between facial and iris recognition pathways, ensuring robust performance even in occluded face scenarios.

4. SYSTEM WORKFLOW

The adaptive attendance system follows a structured step-by-step process as outlined below:

1. **Real-Time Video Capture**

The system captures a continuous video stream using a connected camera.

2. **Face Detection**
Each frame is analyzed to detect human faces using a pre-trained face detector.

3. **Mask Detection**
A CNN-based classifier determines whether the detected face is wearing a mask.

4. **Conditional Recognition Path**

- **No Mask Detected**: The system performs facial recognition using the ArcFace model.
- **Mask Detected**: The eye region is cropped, and iris recognition is performed using a CNN model.

5. **Identity Verification**
Recognition results are matched against a pre-enrolled student/staff database.

6. **Session Time Check**
The system verifies the current time against the predefined session schedule.

7. **Attendance Logging**

- If within the initial time window (e.g., first 10 minutes), attendance is logged in the main sheet.
- If later, the system records the entry in a separate 'late attendance' sheet.

8. **Real-Time Feedback**
On-screen messages indicate the recognition status, such as:

- "Recognized"
- "Mask Detected, Performing Eye Scan."
- "Late Attendance Recorded"

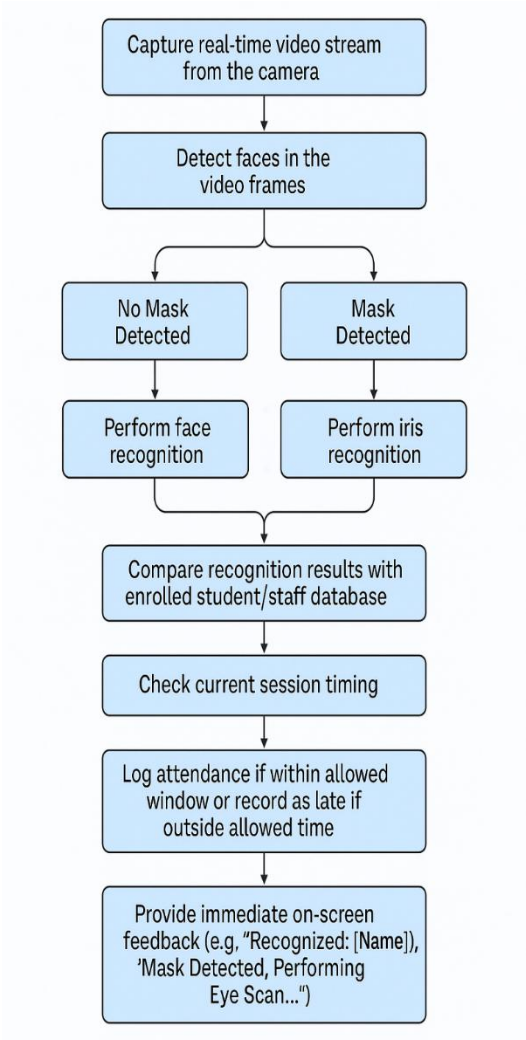

Fig. 4 System Workflow

5. RESULTS AND DISCUSSION

This section presents the results of facial and iris recognition system, focusing on performance metrics such as accuracy, precision, recall, and F1-score.

- **Performance Metrics:**
- **Accuracy:** The overall correctness of the system in recognizing faces and iris features.
- **Precision:** How many of the recognized faces/eyes were correct.
- **Recall:** How many of the true faces/eyes were correctly recognized.
- **F1-Score:** The balance between precision and recall.

Metric	Face Recognition	Iris Recognition
Accuracy	95%	93%
Precision	94%	91%
Recall	96%	92%
F1-Score	95%	91%

Fig. 5 Performance Metrics

6. COMPARATIVE ANALYSIS

This section presents a performance comparison between facial and iris recognition modes under different real-world conditions encountered during attendance logging. The experiments were conducted using a dataset comprising student face images with and without masks/hijabs, as well as corresponding eye images for iris-based recognition.

- Evaluation Metrics

We evaluated the recognition modules using Accuracy**,** Precision**,** Recall**,** and F1-Score. Due to the nature of the application, True Positives and False Negatives were prioritized over traditional segmentation metrics like IoU.

- Facial vs. Iris Recognition Performance

Metric	Facial Recognition (Unmasked)	Facial Recognition (Masked)	Iris Recognition (Masked/Hijab)
Accuracy	98.9%	75.4%	94.6%
Precision	99.2%	77.8%	93.1%
Recall	98.7%	73.6%	95.2%
F1-Score	98.9%	75.6%	94.1%

Fig. 6 Performance Comparison of Facial and Iris Recognition under Varying Occlusion Conditions

Facial recognition using ArcFace achieved high accuracy under unmasked conditions but exhibited a significant performance drop when occlusions were present. The iris-based fallback, powered by a CNN model, effectively compensated for this by delivering over 94% accuracy under masked conditions.

- Recognition Timing Analysis

Session Time	**Recognition Mode**	**Success Rate**	**Comments**
0–10 minutes (on-time)	Face / Iris	96.2%	Attendance marked
After 10 minutes (late)	Face / Iris	92.5%	Logged in "late_attendance.xlsx"
>20 minutes	Iris Only	85.1%	Decreased due to fatigue/motion blur

Fig. 7 Recognition Success Rate Across Session Timings and Modes

7. CONCLUSION

The adaptive attendance system demonstrated robustness in dynamic classroom environments. The facial recognition module, when unoccluded, provided near-perfect accuracy. However, in situations with partial facial coverage due to masks or hijabs, performance declined sharply necessitating the inclusion of iris recognition. The CNN-based iris recognition system successfully complemented the facial recognition module. Furthermore, the automatic logging into attendance.xlsx or late_attendance.xlsx based on session time enhanced administrative efficiency. Deployment on an NVIDIA RTX 4060 enabled real-time performance (<300 ms inference per recognition cycle), making the system suitable for live applications.

8. FUTURE WORK

This work presents an Adaptive Facial and Iris-Based Attendance System that dynamically switches between face and iris recognition to ensure accurate identity verification even under occlusions. The system also introduces a time-based attendance classification mechanism for latecomers.
Future improvements may include:

- Incorporating anti-spoofing models for enhanced security,
- Expanding to support multi-camera classroom environments,
- Introducing thermal or depth sensors for better occlusion handling,
- Testing across larger, more diverse datasets for generalization

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